White Paper: a story about transmission technology for live case transmissions and medical congress support

Introduction…

Over the last decades thanks to the development of audiovisual technologies it has become possible to bring the action and reality of the operating room or cathlab in the hospital to the medical conferences in the congress centre. One of the key aspects are the transmission technologies which are used for video transmission and two way communication. This document provides an insight in the different options and the technological (r)evolution that has inevitably taken place over the last 20 to 30 years. It clearly explains why we do, what we do today to allow that presentations are combined with the day-to-day reality of the medical procedure. This offers direct question and answer with expert professors in the field and leads to an improved educational impact and steeper learning curve.

WHITE PAPER: TRANSMISSION TECHNOLOGY OVER THE LAST 30 YEARS...

From the early days on we discovered that the transmission is a very important aspect in the whole chain leading up to a successful live surgery event. While in the beginning (late 80', early 90's) we mainly saw in-hospital transmissions using direct cable connections, we also witnessed the first applications of wireless transmissions and even satellite connections.

Among our first investments hence one could find kilometres of copper coax cable, cable compensators and humbuckers. Learning how to deal with a composite PAL video signal that had to be transported over a few hundreds of meter of BNC cables was already a big step. We quickly learned about the importance of the thickness, impedance and quality of the cables and the connectors and the influence that e.g. power cables nearby could have on these. We soon entered the YUV / RGB phase with much higher quality standard definition images, and also the higher bandwidth, higher frequency, analogue computer resolutions proved to have their own specific requirements and problems. Not many companies have such a huge collection of Extron splitters and compensators as we (still have).

Soon we invested in a Canobeam, an infrared laser system, which is until now one of the finer pieces of transmission technology ever invented. We became real specialists in the use of these and have done many hundreds of live surgery transmissions over distances of 7-8 kilometres (while it was rated up to 4 kilometres). Bidirectional, 4 composite video channels, 10 audio channels, remarkable quality and stability. We even combined sets and used hub stations to cross longer distances between hospitals and venues. Our transmissions between the Upper East Side Lennox Hill Hospital (NY, US) and the Equitable Center in Midtown Manhattan are historical. We managed to cross the city in full broadcast quality, for that time, without any problems with the interferences of a crowded RF spectrum like is to be found in such a city.

Soon, in Europe, we also learned to work with the national telecom companies and make use of their microwave infrastructure. Still analogue and SD, but very stable and crossing 10's of kilometres, often involving huge antennas on trucks, buildings and backbones, we made full use of that kind of connections. Again, there was no digital video at that time. We still had to deal with composite or YUV/RGB PAL and NTSC...

However, there already existed SNG trucks, completely analogue, with big dishes, powerful phase combined amplifiers and using so called "exciters" (analogue modulators). Some of our higher end jobs where done using analogue satellite connections, needing the bandwidth of almost full transponders of 36 MHz. Imagine the costs involved in that era!

In the US we learned to make use of the telecom companies' fibre infrastructure. The US already had a very good fibre network consisting of high capacity backbones between the cities, and lots of "last mile" connections to hotel, venue and hospital basements. It was possible to order point to point connections for occasional us in a way that actually never has been possible in Europe. The telco providers delivered their own "fibre converters" however at both ends, and the routing via many nodes was not always that straightforward and reliable. And the video was still analogue...
In many US cities' high rise buildings an extensive fibre optical network is installed. We learned quickly how to make use of that and became specialists in connecting all kinds of fibre and converters. Especially since now SDI, serial digital interface, video became the standard. Still standard definition PAL and NTSC, and limited to 270 Mbps, but the advantages for crossing long distances and embedding several audio channels were clear. That was early 2000's.

And then there was video compression! MPEG2 quickly becoming the standard and opening the way to digital SNG. Bandwidths of 9 MHz could support data rates of up to 10 Mbps and satellite transmissions suddenly became more affordable. For years we were very good clients of the pioneering SNG companies like BT, Intrax etc.

While starting to invest in digital equipment we decided to skip the SD SDI phase altogether and jumped to HD directly. 1080i became our standard as soon as 2006. We were among the firsts to use HD in such a general and comprehensive way and it gave us a kickstart into a new and exciting world of high quality and high resolution imaging.

The needs for higher bandwidths (HD SDI is 1,5 Gbps) and data rates meant again better cables, reclockers, adapted fibre converters and of course video encoders. Already in 2006 we purchased our first state of the art MPEG4 HD Tandberg encoder, and at once we started experimenting with the newest modulation techniques and transmission methods.

Right now our primary means of transmission is satellite. There are plenty of satellites in geostationary positions covering all continents that have capacity for OU (Occasional Use) television transmissions. These days we are also very independent from external suppliers because we operate our own up- and downlinks and have direct booking channels to many different satellites all over the world.

We own and operate 4 satellite uplinks, one mobile and three "fly away" systems. They are all fully redundant with HD encoders, DVB-S2 modulators, full bandwidth up converters and powerful HPA's. The size of our uplink dishes varies from 2.6m to 1.2m. Our lightest fly away set only weighs 60 kg in total and consists of 3 bags that can easily be checked in as luggage on any commercial flight. We typically can send a dual HD feed of 18 Mbps using only 9 MHz, the bandwidth which has always been used for standard definition transmissions. Satellite remains one of the cheapest and certainly most reliable means of transmissions for our needs.

In terms of down-linking we have many solutions for Ku-band and C-band, with dishes up to 2.7m. We also invested a lot in RF-over-fibre solutions, high end spectrum analysers and top of the range demodulators, decoders and IRD's (integrated receiver decoders) for DVB-S2 and MPEG2/4. We do all our downlinks ourselves, whether we are on a live surgery job in Europe, the US, Brazil or Australia and New Zealand.

In some instances we have to use double or triple hop connections for transmissions from Asia or New Zealand to Germany, e.g. for some congresses we co-ordinate and manage 5 parallel satellite connections for transmissions from 11 live sites, all over the world, at once. We have been building temporary teleports in Leipzig, Hong Kong and New Orleans for such events.

Our second most used means of transmission is... Wi-Fi. Over the years we gained a huge experience with operating temporary point to point Wi-Fi connections using the free 5.5 GHz band. We can easily set-up IP-links of 80-100 Mbps over 10 kilometres and more, staying within the legal power limits of 1W. We can send all kinds of signals via these connections, most typically bidirectional ASI-muxes containing several MPEG2/4 HD feeds. We also own a whole "farm" of HD videoconferencing equipment, such as a dozen of Sony Ipela, that can be used over any IP-connection, with an image quality of unto 8 Mbps bidirectionally! Wi-Fi is the cheapest transmission system, because the "capacity" is free, but it requires a serious experience and knowhow and basically the same (expensive) equipment as satellite in terms of encoders, muxers, decoders...

We are also the proud owners of extremely high end Gigawave digital microwave systems operating in the 7 GHz band. These transmitters and receivers, that can be used in a bidirectional configuration also, can easily cover 30 km point-to-point, maintaining bandwidths of unto 85 Mbps. Of course the 7 GHz band is strictly regulated and has only limited licensable channels for occasional use. However it can be a perfect solution for multi day transmissions over longer distances. We even own a 30m high retractable antenna mast that can be used on location where a roof is not high enough for instance.

And then there is still fibre... Where distances allow for it, or where a local fibre optical infrastructure is present, we can do wonders with fibre optical connections. We are very experienced and very well equipped for managing all kinds of situations. Besides literally tens of kilometres of multi-strand fibre, we have hundreds of fibre converters (from brands like Telecast and Yellobrik), for all possible formats, from analogue audio over 1 Gbps ethernet to 3G and even 4K video. And all needed tools in term of fibre measuring devices, fibre splicers (to repair our fibres ourselves) and all possible connector-patches.

For situations where the internet can be a viable alternative for a live surgery transmission we have many solutions as well. From the typical low data rate (<2-4 Mbps) videoconferencing devices (EdBox, Cisco Telepresence,...) which we try to avoid by all means because of the inferior quality and reliability, on to our own 3G/4G bundling equipment and data network that routes a feed of 8-11 Mbps to our datacentre where we have a direct access to an internet backbone. We also offer hybrid solutions where we use satellite to uplink a feed from a hospital to our offices where it is down-linked and directly transferred to our high capacity internet connections for distribution via a video server network as a webcast or for a point-to-point IP-connection with a venue. We also own KaSat internet-via-satellite dishes (15 Mbps DL and 4-5 Mbps UL) for use in places with limited internet access.

For the return sound (the questions from the moderators or audience to the doctors in the operating room or the cathlab) and for the intercom (background communications between technicians in the venue and at the hospital) we either use the bidirectional properties of the Wi-Fi, videoconferencing systems or fibre optical connections, or telephone lines connected to digital hybrids. Small bandwidth IP-connections can also be used with special codecs and compression protocols.

In any case, maintaining lip sync and dealing with the inevitable audio delay and latency that's caused by encoding / decoding or by the travel of the signal through space (roughly 37.000 km to the satellite from the uplink and 37.000 back to earth to the downlink) is a specialty on itself. Much attention is given to this by us and special measuring and sound processing equipment is used for this.

We can safely state that in the area of broadcast signal transmissions we have seen it all, done it all and are now among the most experienced and well equipped companies in our field. Interesting to tell here is also that while we gained a lot of experience over the last 5 years in mastering 3D imaging techniques for live surgery and recording surgical cases, we also had to develop ways for transmitting 3D without having to double our bandwidth needs and transmission budgets. We have now ways to transmit up to three full 3D stereoscopic images using only 18 MHz of bandwidth without sacrificing quality. This technology is also used by us for transmitting dual feed HD live surgery, where one feed shows mainly camera images and external views and the other mainly medical images. This is now our standard of working, especially since most of our meeting room set-ups use seamless widescreen projection.

4K/UHD is next. The target of 2.160p becoming our new video standard very soon also forces us to find solutions for transporting these signals. At this point in time there are hardly any 4K/UHD encoders commercially available, neither in MPEG4 nor in HEVC (which will become the new encoding standard, also dubbed MPEG5). This means that our efforts currently still focus on encoding and transmitting the 4 "quadrants" of a 3.840 x 2.060 separately and recomposing the image at the level of projection... This is quite a challenge!

Parameter Form

Subject	Parameter		Remark
Bandwidth	9MHz		
Satellite	ASIA SAT5 100.5°E C-band		Transponder C7H Channel Ch3 ULF
24 hour control center number of Satellite	RR-SAT Israël +972 299 04466 & +972 886 10001		Uplink contact BELDBA Essen Germany
U/L and Polarity	5,109 50V		Operator: Roland Beels Cellphone +31 6 116 40 283
D/L Frequency and Polarity	3,884.50H		
Source	HD		
Aspect Ratio	16:9		
Video Standard	PAL 1080i50		
Encode			
	MPEG-4 4:2:0		
	8Bit		
Encryption	NO		
Videc	Digital		
Audio	Embed		
	Channel 1:mono N-1	Channel 2:mono Full program	
		DO NOT USE!	
Modulace Method	8PSK		Roll Off 20%
Symbol Rate	7.000msymb		Datarate 16,956
FEC Schema Forms	DVB-S1		Pilot: ON
FEC	5/6		
Test Time(GMT)	Tuesday 24th March 14:00-14:30GMT		Booking ID 225520
Use Time (GMT)	Wednesday 25th March 07:00-17:15GMT		Booking ID 225521

A typical satellite transmission schedule

MEDIAVENTURES

AUDIOVISUAL PRODUCTIONS FOR THE MEDICAL, MORE ADVENTUROUS WORLD

Executive Summary...

mediAVentures uses several systems for transmitting live surgery images and sound from a hospital to a meeting room.

Fibre optical cabling

For in campus transmissions and for distances up to one kilometre we can temporarily install multi-strand (typically 8 strands per cable) and tactical quality (reinforced) fibre optical cables. These allow for high quality, uncompressed, bidirectional multi-feed connections between operating rooms or cathlabs and an auditorium within the hospital compound. Also, in multi-OR transmissions, where several OR's and cathlabs or examination suites have to be connected to a central control room, lots of fibre optical cabling are involved.

Satellite

The use of satellite connections is still the gold standard for high end live surgery transmissions worldwide. All major live surgery conferences (like TCT, LINC, PCR, ESC, CRT, NCVH, EAU...) use it for their international and intercontinental transmissions. Satellite has become more affordable, reliable and high-quality than ever. We operate our own uplinks and downlinks and manage the satellite capacity ourselves, allowing for very competitive connection budgets. Using ultra modern encoding, muxing and modulation technology we can transmit multi feed HD and 3D at lower bandwidths than used to be needed for SD. Even UHD/4K is on our horizon.

Wi-Fi

For direct point-to-point transmissions between a hospital and a venue within a city, e.g., over distances of 10 km and more, we use specialised Wi-Fi equipment and the free 5.5 GHz band that allows for stable bidirectional connections of 80-100 Mbps. We can do multi-hop by using a relay point in between and cover longer distances or avoid obstacles blocking the line of sight between origin and destination. Using IP encapsulating we can transmit multiple HD feeds in both directions. We can also connect high end videoconferencing equipment with data rates of up to 8 Mbps. This is an ideal solution for conferences of more than one day with many cases and long transmission times.

Microwave

With the same functionalities as Wi-Fi, and data-rates of up to 85 Mbps, digital microwave transmissions in the 7 GHz band can cover distances of up to 30 km and can be operated more reliably in the saturated RF environments of big cities. This needs licensing however and OU (occasional use) frequencies are not always readily or cheaply available.

Internet and IP

In certain conditions the use of internet can be considered for point-to-point transmissions as well. Most hospitals however have limited upload speeds (typically less than 2-4 Mbps) and are heavily protected by firewalls and port restrictions. Nevertheless, sometimes videoconferencing equipment can be used at these data-rates if image quality is not critical and projection screen size is rather limited. We do circumvent these restrictions by using 3G/4G/LTE bundling with direct connectivity to our own data network that allows for direct access to the internet backbone. Upload speeds of 6-8 (sometimes even 11) Mbps can be reached and much higher quality HD video quality can be streamed to a venue, with an acceptable latency. Such a set-up has to be tested extensively beforehand of course and this technology is also not suited for long transmission times because of the cost per Gb of mobile internet connections.

Over the last 20 years mediAVentures has been involved in the transmission of more than 2.000 live surgery cases. Each year we perform live surgery transmissions from Europe, the Americas, Asia and Australia in cardiothoracic surgery, cardiology, neurosurgery, orthopaedics, urology, gynaecology, bariatric surgery... (basically all medical fields).

Contact us for more information or specific questions on wimsamyn@mediaventures.be